IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:
Verbist *et al.*
Appl. No.: 10/647,477
Filed: August 26, 2003
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Claim For Priority Under 35 U.S.C. § 119(a)-(d) In Utility Application

Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

Sir:

Priority under 35 U.S.C. § 119(a)-(d) is hereby claimed to the following priority document, filed in a foreign country within twelve (12) months prior to the filing of the above-referenced United States utility patent application:

Country	Priority Document Appl. No	Filing Date
United Kingdom	GB 2, 366,461	August 31, 2000

A certified copy of each listed priority document is submitted herewith. Prompt acknowledgment of this claim and submission is respectfully requested.

Respectfully submitted,

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o certify that subject to the payment of the prescribed renewal fees, the patent will remain rce for a period of twenty years from the date of the filing of the application.

her certify that attached hereto is a true copy of the entries made to date in the Register of ts in respect of the patent which is in force.

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Re- stration under the Companies Act does not constitute a new legal entity but merely sub he company to certain additional company law rules.

Signed

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H03F 1/02

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H3W WUS
H3T T6E

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WO 99/18662 A1 US 5898342 A
US 4873493 A

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(54) Abstract Title
A power supply for an operational amplifier in which the required voltage for a particular output may be selected from a plurality of supply voltages

(57) A power saving supply for an operational amplifier is described, in which the required voltage for a particular output may be selected from a plurality of supply voltages. The selection may be made on the basis of values, for example peak or average, of input digital signals. Use in a digital subscriber line (DSL) driver is disclosed.

FIG 1

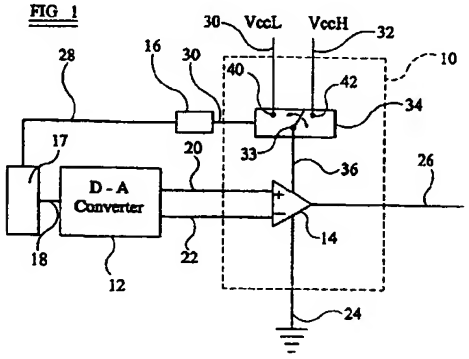

FIG 2

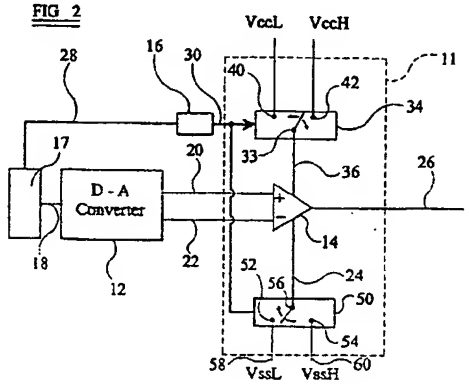

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FIG 1

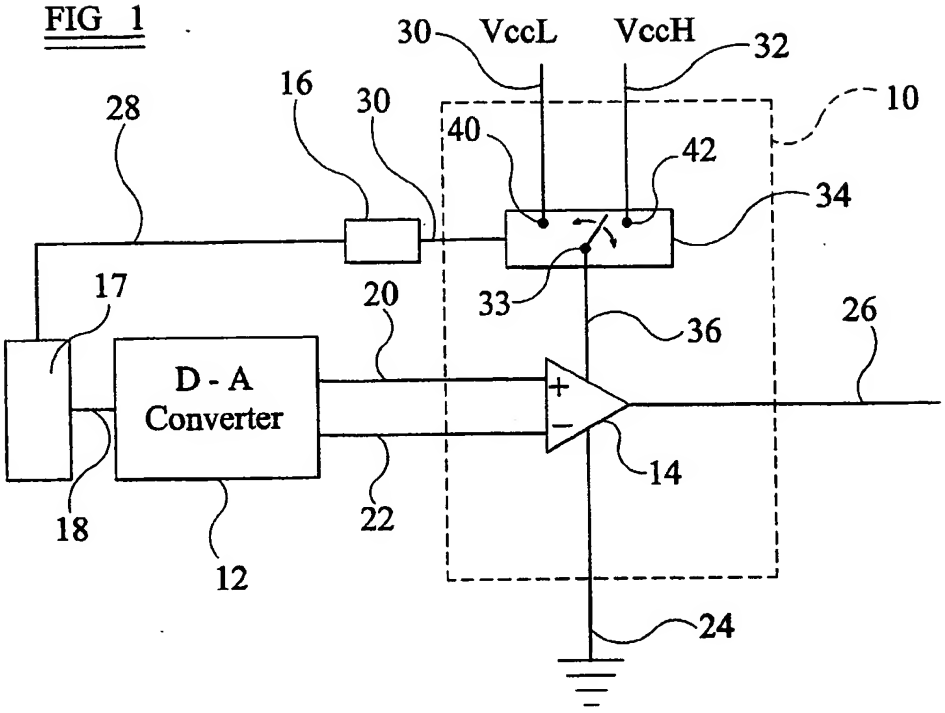
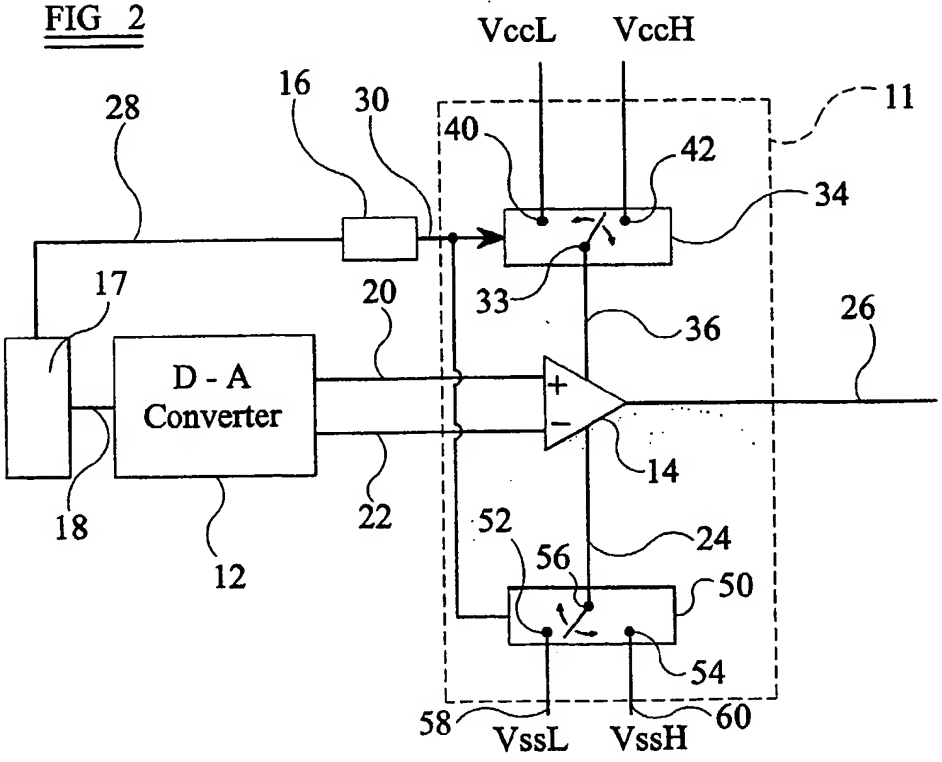

30
VccL
VccH
32
10
16
30
28
40
42
34
17
20
33
36
26
D - A
Converter
+
−
14
18
22
12
24

FIG 2


VccL
VccH
11
16
30
28
40
42
34
17
20
33
36
26
D - A
Converter
+
−
14
18
22
12
52
24
56
50
54
58
VssL
VssH
60

2366461

SWITCHED SUPPLY FOR OPERATIONAL AMPLIFIER

The present invention relates to a technique for providing supply voltages to a supply terminal of an operational amplifier.

In certain applications the voltage levels to which an operational amplifier is required to drive signals is variable. Thus, for example, the operational amplifier may at times be required to drive output signals to a voltage level of 15 volts, whilst at other times it may only be necessary to drive output signals to a voltage level of 5 volts. However in order to cover the full range of possible output voltage levels, the operational amplifier is required to be provided with the voltage supply corresponding to the highest voltage level, namely in this example 15 volts.

It is therefore an object of the present invention to provide an improved technique for providing a supply voltage to a supply terminal of an operational amplifier.

In accordance with a first aspect of the present invention there is provided a circuitry for providing a supply voltage to an operational amplifier, comprising:

a switch having a plurality of inputs connected to a respective plurality of supply voltages, and an output connected to a supply voltage terminal of the operational amplifier, wherein the input of the switch is selected in dependence on the voltage level to which a signal is to be amplified. Thus, advantageously the operational amplifier is only provided with a supply voltage level corresponding to the highest voltage level to which it requires to drive a signal, thereby saving power consumption when only low voltage levels are needed.

A digital to analogue converter may receive digitised values, and generate a corresponding analogue signal for amplification by the operational amplifier. The input of the switch may be selected in dependence on the digitised values. The input of the switch may be selected in dependence on either the peak digitised value of the digitised values or the average digitised value of the digitised values. The average digitised value is used if the peak-to-average ratio (PAR) is known for the digitised values.

The input of the switch may be selected by a control signal generated in dependence on the digitised values. The digitised values may be provided by a digital signal source.

Preferably the switch has a first and a second input connected to a respective first and second supply voltages, a first supply voltage being lower than the second supply voltage, wherein the input of the switch is selected to be the second input if the voltage level to which the signal is to be amplified exceeds a predetermined level.

The circuitry for providing the supply voltage to the operational amplifier may further comprise:

a further switch having a plurality of inputs connected to a respective plurality of further supply voltages, and an output connected to a further supply voltage terminal of the operational amplifier, wherein the input of the further switch is selected in dependence on the voltage level to which the signal is to amplified.

In a further aspect the present invention provides a method of providing a supply voltage to an operational amplifier, comprising the steps of :

providing a plurality of supply voltages; selecting one of the supply voltages in dependence on the voltage level to which a signal is to be amplified; and connecting the selected one of the plurality of supply voltages to a supply voltage terminal of the operational amplifier.

The method may further comprise the step of converting digitised values into an analogue signal for amplification by the operational amplifier. The step of selecting one of the supply voltages may be dependent upon the digitised values. The step of selecting one of the supply voltages may be dependent upon either the peak digitised value of the digitised values, or the average digitised value of the digitised values. The average digitised value is used if the peak-to-average ratio (PAR) is known for the digitised values.

The step of selecting one of the supply voltages may include generating a control signal in dependence of the digitised values.

Preferably there is provided a first and second supply voltage, the first supply voltage being lower that the second supply voltage, wherein the second supply voltage is selected if the voltage level to which the signal is to amplified exceeds a predetermined level.

The method of providing the supply voltage to the operational amplifier may further comprise the steps of:

providing a plurality of further supply voltages; selecting one of the further supply voltages in dependence on the voltage level to which a signal is to be amplified; and connecting the selected one of the plurality of further supply voltages to a further supply voltage terminal of the operational amplifier.

The circuitry for providing the supply voltage to the operational amplifier, or the method for providing a supply voltage to the operational amplifier, may be associated with an xDSL modem. A DSL is a digital subscriber line. The term "x" in front of DSL implies that the invention is relevant to any type of digital subscriber line technology. For example, the invention is relevant to ADSL (asymmetric digital subscriber line) technology, the VDSL (very-high-data-rate digital subscriber line) technology, HDSL (high bit rate digital subscriber line) technology etc.

The invention will now be described with regard to a non-limiting example by way of reference to the accompanying drawings in which:

Figure 1 illustrates a first embodiment of a circuitry for providing a supply voltage to an operational amplifier in accordance with the present invention; and

Figure 2 illustrates a second embodiment of circuitry for providing a supply voltage to an operation amplifier in accordance with the present invention.

The following example of the present invention is described with specific reference to an application in an ADSL (asymmetric digital subscriber line) implementation. It will be apparent

to the person skilled in the art that the present invention is generally applicable to any operational amplifier implementation.

Referring to Figure 1, the operational amplifier block according to the present invention as shown in this embodiment is generally designated by reference numeral 10. The block comprises an operational amplifier 14 and a switch 34. For the purposes of describing the present invention in this example there is also provided a digital to analogue converter 12 a digital signal source 17 and a logic gate 16. The digital to analogue converter 12 receives digital values on line 18, from the digital signal source 17 and generates an analogue signal on lines 20 and 22 to the positive and negative inputs of the operational amplifier 14 as is well known in the art. The operational amplifier 14 has a first supply voltage terminal 36 connected to a node 38 of the switch 34. A second supply voltage terminal 24 of the operational amplifier 14 is connected to ground. The operational amplifier 14 generates amplified analogue signals on line 26. A switch 34 has two additional nodes 40 and 42. Node 40 is connected to a supply voltage V_{CCL} on line 30. Node 42 is connected to a supply voltage V_{CCH} which is connected to line 32. An output of the digital signal source on line 28 is provided to logic gate 16 which in turn provides a control signal on line 30 to the switch 34.

As can be illustrated by the arrows within the switch unit 34, the switch 34 is controllable to connect node 38 to either the node 40 or 42. In this way the first supply terminal 36 of the operational amplifier receives either the supply voltage V_{CCL} on line 30 or the supply voltage of V_{CCH} on line 32.

The digitised values provided on line 18 to the digital to analogue converter 12 are indicative of the voltage levels to which the analogue signal on the output on line 26 of the operational amplifier are to be driven to. Thus, these values are indicative of the supply voltage level, either V_{CCL} or V_{CCH}, which the first supply terminal 36 of the operational amplifier should be connected to. The digital signal source 17 will generate a signal on line 28 in dependence on the digitised value output on line 18. Thus the logic gate 16 will generate a signal on its output 30 in dependence on the value of line 18 provided to the digital to analogue converter 12 meeting

certain predetermined conditions. Thus the digital signal source 17 may be configured to detect a digitised value above a certain threshold value, and responsive thereto may set the signal on line 28 to switch to the higher supply voltage V_{CCH}.

Alternatively, rather than the digital signal source 17 being configured to switch to a high supply voltage responsive to a single peak being detected above a threshold level, the digital signal source 17 may be adapted to accumulate the digitised values and determine the average value thereof, and only response to the average value being above a peak is the control signal 28 set to switch to the higher supply voltage V_{CCH}.

The supply voltage is selected dependent on the average digitised values if the peak-to-average ratio (PAR) is known for the digitised values.

Referring to Figure 2, there is illustrated a second exemplary embodiment for controlling an operational amplifier according to the present invention. Like reference numerals are used to denote elements corresponding to elements shown in Figure 1.

Thus, as can be seen from Figure 2, the operational amplifier block, designated by reference numeral 11, is modified to include a further switch 50 for controlling a supply voltage provided to the second supply voltage terminal 24 of the operational amplifier 14. The second supply voltage terminal 24 of the operational amplifier 14 is connected to a node 56 of the switch 50. The switch 50 additionally comprises two nodes 52 and 54. The node 52 is connected to the supply voltage level V_{SSL} on line 58, and node 54 is connected to a supply voltage level V_{SSH} on line 60. In addition the switch 50 receives the control signal on line 30 from the logic gate 16.

The operation of the general circuit of Figure 2 is exactly the same as Figure 1, with the exception that the control signal 30 now additionally controls the supply voltage applied to the second supply voltage terminal 24 of the operational amplifier. Thus, by way of example, the voltage level of V_{CCL} may correspond to plus five volts, and the voltage level of V_{SSL} correspond to minus five volts. In normal operation, the switches 34 and 50 may have a default setting in

which the supply voltage terminal 36 is connected to the voltage V_{CCL}, and the supply voltage terminal 24 is connected to the voltage V_{SSL}. In this example, it may be considered that the voltage level V_{CCH} is plus fifteen volts and the voltage level V_{SSH} is minus fifteen volts. Responsive to the appropriate peak or average levels being detected in the digitised signals by the logic gate 16, the line 30 is set such that the switch 34 switches to connect the voltage V_{CCH} the supply voltage terminal 36, and the switch 50 switches to connect the supply voltage terminal 24 to the supply voltage level V_{SSH}.

Thus it can be seen that with the use of the present invention power can be conserved by only applying the high voltage levels to the operational amplifier when it is required to amplify a signal to a higher voltage level.

The digital signal store may be considered to generally represent any technique by which digitised values are generated. The digital signal source may alternatively be a buffer provided in a digital stream. The digital signal source may be provided purely for the detection of peak signals or average values for the purpose of controlling the switch 10.

CLAIMS:

1. Circuitry for providing a supply voltage to an operational amplifier, comprising:

a switch having a plurality of inputs connected to a respective plurality of supply voltages, and an output connected to a supply voltage terminal of the operation amplifier, wherein the input of the switch is selected in dependence on the voltage level to which a signal is to be amplified.

2. Circuitry according to claim 1 further comprising a digital to analogue converter for receiving digitised values and for generating a corresponding analogue signal for amplification by the operational amplifier.

3. Circuitry according to claim 2 wherein the input of the switch is selected in dependence on the digitised values.

4. Circuitry according to claim 3 wherein the input of the switch is selected in dependence on the peak digitised value.

5. Circuitry according to claim 3 wherein the input of the switch is selected in dependence on the average digitised value.

6. Circuitry according to any one of claims 2 to 5 wherein the input of the switch is selected by a control signal generated in dependence on the digitised values.

7. Circuitry according to claim 4 wherein the digitised values are stored.

8. Circuitry according to any preceding claim, wherein the switch has a first and a second input connected to respective first and second supply voltages, the first supply voltage being lower than the second supply voltage, wherein the input of the switch is selected to be the second input if the voltage level to which the signal is to be amplified exceeds a predetermined level.

9. Circuitry for providing a supply voltage to an operation amplifier according to any preceding claim, comprising:

a further switch having a plurality of inputs connected to a respective plurality of further supply voltages, and an output connected to a further supply voltage terminal of the operational amplifier, wherein the input of the further switch is selected in dependence on the voltage level to which the signal is to be amplified.

10. An xDSL modem including circuitry according to any one of claims 1 to 9.

11. A method of providing a supply voltage to an operational amplifier, comprising the steps of:

providing a plurality of supply voltages; selecting one of the supply voltages in dependence on the voltage level to which a signal is to be amplified; and

connecting the selected one of the plurality of supply voltages to a supply voltage terminal of the operational amplifier.

12. The method of claim 11 further comprising the step of converting digitised values into an analogue signal for amplification by the operational amplifier.

13. The method of claim 12 wherein the step of selecting one of the supply voltage is dependent upon the digitised values.

14. The method of claim 13 wherein the step of selecting one of the supply voltages is dependent upon the peak digitised value.

15. The method of claim 13 wherein the step of selecting one of the supply voltages is dependent upon the average digitised value.

16. The method of any one of claims 12 to 15 wherein the step of selecting includes generating a control signal in dependence on the digitised values.

17. The method according to any one of claims 11 to 16 in which there is provided a first and a second supply voltage, the first supply voltage being lower than the second supply voltage, wherein the second supply voltage is selected if the voltage level to which the signal is to be amplified exceeds a predetermined level.

18. A method of providing a supply voltage to an operational amplifier according to any one of claims 11 to 17 comprising the steps of:

providing a plurality of further supply voltages;

selecting one of the further supply voltages in dependence on the voltage level to which a signal is to be amplified; and

connecting the selected one of the plurality of further supply voltages to a further supply voltage terminal of the operational amplifier.

19. A method of providing a supply voltage to an operational amplifier of an xDSL modem according to any one of claims 11 to 18.

Application No:	GB 0021438.7	**Examiner:**	D Midgley
Claims searched:	1-19	**Date of search:**	9 March 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): H3W WUE,WUS

Int Cl (Ed.7): H03F 1/02

Other: ONLINE:WPI,EPODOC,JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	WO 99/18662 A1	(ERICSSON) See, for example, page 10, lines 3-19 and figure 9.	1-4,6-14,16-18
X	US 5898342	(ADVANCED) See, for example, figure 2 and description thereof.	"
X	US 4873493	(VICTOR) See, for example, figure 2 and description thereof.	"

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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RENEWAL DETAILS

PUBLICATION NUMBER GB2366461

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YEAR OF LAST RENEWAL 06

STATUS PATENT IN FORCE

**** END OF REPORT ****

For Innovation

REGISTER ENTRY FOR GB2366461

Form 1 Application No GB0021438.7 filing date 31.08.2000

Title SWITCHED SUPPLY FOR OP-AMP

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H03F

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Title of Granted Patent SWITCHED SUPPLY FOR OPERATIONAL AMPLIFIER

02.03.2001 Notification of change of Address For Service name and address of
PAGE WHITE & FARRER, 54 Doughty Street, LONDON, WC1N 2LS, United Kingdom [ADP No. 00001255003]
to
ELKINGTON AND FIFE, Prospect House, 8 Pembroke Road, SEVENOAKS, Kent, TN13 1XR, United Kingdom [ADP No. 00000067004]
dated 09.02.2001. Official evidence filed on GB0021438.7
Entry Type 7.1 Staff ID. KR Auth ID. F51

23.06.2004 Name and address maintenance action has taken place and the address for Address For Service is
ELKINGTON AND FIFE LLP, Prospect House, 8 Pembroke Road, SEVENOAKS, Kent, TN13 1XR, United Kingdom [ADP No. 08875429001]
this change is effective from 27.05.2004
Entry Type 7.5 Staff ID. AR Auth ID. NA20

**** END OF REGISTER ENTRY ****